# AIR POLLUTION CONTROL THROUGH KILN RECYCLING BY-PASS DUST IN A CEMENT FACTORY

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## ABSTRACT

Air pollution is a major problem in the industrial areas. Cement dust is one of the important environmental pollutants. In this study the possibility of dust recycling especially kiln dust which has significant importance regarding air pollution in the cement plant, was examined. Tehran cement factory is one of the most important Iranian factories which is located in Tehran. This factory produces high volume of pollutants that are released to in environment. The possibility of reusing of kiln by pass returned dust has been examined in this factory. Different percentages of kiln by-pass dust of this factory were added to products and outcomes of its presence in parameters such as chemical compound, granulation, primary and final catch time, volume expansion, consumed water and resistance of mortar were surveyed. The result indicated that by adding the amounts of 3-8 dust the mortar resistance increase, but adding more than 15%, the mortar resistance has been decreased. Survey in consumed water proved that adding dust to cement, the trend for consuming water is decreased. After dust addition dust, primary and final catch time were compared in different samples and data which showed decrease in dust added samples. Cements with dust added showed increase in auto clave expansion. Overally, results proved that, the best percentage rate of dust addition to the cement was 15%.

**Key words:** Cement, by pass dust, kiln, resistance, volume expansion

## INTRODUCTION

Over the centuries, air pollution has increased from a local nuisance to a global problem (Emberlin 1998). Cement industry is one of the most important and strategic industries in Iran. However, its air pollution has been a serious problem. The primary related pollution is dust, which industrial countries have allocated tremendous efforts in reducing its volume. Dust in different stages of a production line of cement is dispersed and by suitable dust catcher will be collected. The collected dust, often from combination point of view is similar to circulation materials at the same area of process and for this reason is returned to the production line (Mohsenzadeh, *et al.*, 2006). In the past, cement kiln dust was kept as industrial wastage, but recently it is emphasized for its application, because a considerable amount of energy has been to be paid for its preparation, calcinations and so discarding it, bring out wastage of energy and cost. On the other hand, due to consideration of high volume of the collected dust, a lot of costs were allocated by collection and destroying it, due to have some special chemical compound which, has adverse environmental effects (Chehregani, 2005). Different scientific and technical sources and the following applications have been introduced. As reinforcement in asphalt concretes, it helps its high strength and life (Debell, M., 1997), as it contains materials such as $K_2O$, $CaO$,$Na_2O$ helps to stabilization of sewage sludge (Holdereank Seminar, 2000). By pass dust of rotating kiln due to fine granulation can absorb $SO_2$ from power supplies (Tettmar, B. *et al.*, 2003). On the other hand, after washing the dusts with

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water, (which resulted in dissolution of unfavorable alkaline and chloride ingredients) with drying , the dust is returned to raw materials of production line, of course, it requires consumption of water and results in its dirtiness (Yazeed, S.A. *et al.*, 1994). One of the other applications is chemical fertilizer or artificial soil. The other application is production of clinker from dust through a reactor or fluid bed, preparation of brick and other construction materials (Makrom, 1999). Among the mentioned processes, attention can be paid to direct application of by-pass dust from cement kiln as additive. Because firstly, it causes increase in cement production and secondly, its easiness and cost without consuming energy and without any process for conducting any operation (Chehregani, 2005). By-pass dusts are from outlet gases in suspension kiln and in inverse conditions are in circulation with materials. These dusts due to alkaline materials and volatility of raw material and perhaps fuel, have high volatility and probably with cooling in some sections of baking process, they are deposited and causes catching and interior cycles. Its production quality is in term of type of materials, production technology. Operational conditions are 3 up to 20 percentages of production, for example in a kiln with capacity of 2000 tons per day, and in the cement production about 10 up to 12 tons per hour are produced. Distribution of by pass dust granulation of cement kiln includes 80-90 percentage of particles less than 45 microns. Particles less than 4 micron constitutes about 30% of total dust (Debell, 1998 and Wirthwein, 2002).

## MATERIALS AND METHODS

*Sample preparation*

The sample were prepared to assess percentage of optimize added by-pass dust (returned dust) to the product. The cement preparation samples were type 2 from Tehran cement factory:

a. These samples are contained no by-pass dust for assessment.
b. Samples contained by-pass dust, have been coded respectively according to Table 1.

Table 1: Coding of samples with different percents of by pass dust

| Amount of by pass dust (percent) | Sample code |
|---|---|
| 3 | S1 |
| 4 | S2 |
| 5 | S3 |
| 6 | S4 |
| 7 | S5 |
| 8 | S6 |
| 9 | S7 |
| 15 | S8 |
| 20 | S9 |

The samples were mixed and homogenized. And also tests were conducted for assessment as follows:

*pressure resistance test*

For evaluation, influences of by-pass kiln on cement properties were prepared, in section 4-1 according to DIN 1164 under bending and pressure test. The tested samples from cement according to DIN196-1 EN and distilled water in proportion to 1: 3: 0.5 was prepared and after mixing and molding, it was kept in a wet room for 24 hours. Then samples were brought out of mould and were put in water with 20+1 °C. Then tested samples were put in pressure resistance test for 3, 7 and 28 days, respectively.

*catch time test*

For assessment of primary and final catch time, the Vikat units were used. Standard cement paste, which is required for this purpose and also the measuring of cement expansion, was necessary, and prepared from lab samples. Extent of consumed water is determined for the paste and then, each sample is under test for final and primary catch time.

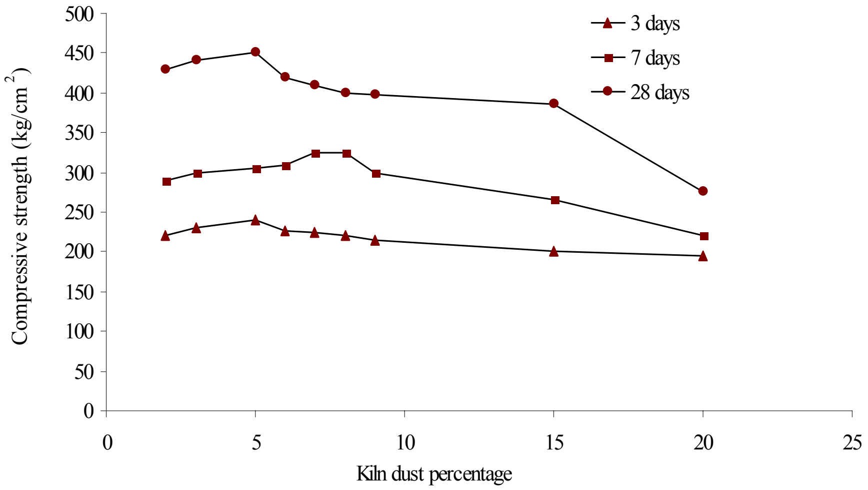
*expansion test and auto-clave*

In this process for determination of probable influence of by-pass dust in hydrate cement properties and especially auto-clave expansion, tested samples with percentage of determined were water provided and after 24 hours from preparation of mortar and molding in the wet room, we put them in the auto-clave under 2 MPa pressure and three hours in 215 °C (ASTM C151-64) after elapse of the time, and cooling of samples, longitudinal variations were measured precisely and their expansion was specified in mm percentage.

## RESULTS

*Results of resistance measurement*

The outcomes of bending and pressure resistance of samples on days 3,7 and 28 are presented in Fig. 1. The outcomes show that by adding dust to cement to the amount of 3-8 percentage, the resistance of cement will be increased and adding dust more than 15% gives rise to reduction in resistance of cement.




*Results of catch time test*

For determination of final and primary catch time, the vilcat unit was applied. Then each sample, were put under test for primary and final catch time. Outcomes of these surveys are reflected in Table 3 results proved that adding dust, the final and primary catch time of cement in the most samples is decreased but in some samples, including samples with 20% dust, the primary catch time has been increased. In samples with 3% dust, the final catch time increased.

*Results of autoclave expansion test*

Results of autoclave expansion test are presented in Table 3, which shows that by adding dust to cement, it causes expansion of autoclave. Also Table 4 shows results of test for determination of special range of tested samples.

Table 2: Results of catch time test for samples with different percents of by pass dust

| Sample code | Percent of additive dust | Ratio of water to cement | Initial catch (mm) | Final catch (mm) |
|---|---|---|---|---|
| Control | 0 | 0.262 | 182 | 255 |
| S1 | 3 | 0.260 | 180 | 258 |
| S2 | 4 | 0.255 | 180 | 232 |
| S3 | 5 | 0.250 | 176 | 215 |
| S4 | 6 | 0.251 | 165 | 207 |
| S5 | 7 | 0.256 | 172 | 196 |
| S6 | 8 | 0.245 | 160 | 225 |
| S7 | 9 | 0.248 | 178 | 236 |
| S8 | 15 | 0.244 | 185 | 232 |
| S9 | 20 | 0.226 | 156 | 226 |

Table 3: Results of autoclave expansion test and specific surface for samples with different percents of by pass dust

| Sample code | Percent of additive dust | specific surface ($cm^2/g$) | autoclave expansion (%) |
|---|---|---|---|
| Control | 0 | 2800 | 0.080 |
| S1 | 3 | 2900 | 0.090 |
| S2 | 4 | 2960 | 0.097 |
| S3 | 5 | 3010 | 0.099 |
| S4 | 6 | 3100 | 0.100 |
| S5 | 7 | 3160 | 0.102 |
| S6 | 8 | 3200 | 0.104 |
| S7 | 9 | 3220 | 0.105 |
| S8 | 15 | 3420 | 0.110 |
| S9 | 20 | 3550 | 0.120 |

## DISCUSSION

Fig. 1 shows that the increase in by pass dust percentage to cement, first causes relative increase in pressure resistance. Of course, this trend has been changed with increase in by pass dust (returned dust) and gradually loss in sample resistance. This trend has been seen in all samples and is the reason for considerably cement phases decrease (C3S,C2S) with increase in dust percentage to cement. According to Table 2, increase in percentage of by-pass dust (returned dust), creates regular trend at considerable decrease or increase ratio of water to cement of tested samples. Anyhow, in this respect, in some sources, the increase of water to cement has been mentioned (Paus, 2001 and Abo-El-Enein, 2001) but against this viewpoint has been seen in some tests. Changes in relation with primary catch time with increase in by-pass dust percentage are not considerable but final catch with increase in by pass dust, sometimes increased and in some cases, showed decrease. Although increase trend in final catch time is predicted because the increase in by pass dust brings about reduction in cement phases and overshadows their hydration process for creation of catch (Cehregani, 2005 and Abo-El-Enein, 2001). Results of autoclave expansion tests (Table 3) show that amount of autoclave expansion which were increased by adding dust to cement. In this process, it is predicted that increase in by pass dust brings about increase in samples of alkaline materials and increase alkaline expansion. Anyhow, by-pass dust, due to having semi calcinations materials, includes free lime (and probably MgO) and this increase, causes expansion of samples. Increase in percentage of by pass dust in samples, brings about increase in their special range. Due to fine granulation, by-pass dust was foreseeable and is from advantages of by pass dust application to cement. The surveys prove that adding kiln by pass dust to cement may be considered as a cheap and easy process. This process preserves raw materials sources, saving energy consumption and prevent is pollution in the environment. With due consideration to outcomes from resistance stand point, the best quantity for adding by-pass dust to the cement, is the MAX curve in Fig 1. In this position, the percentage of added dust to optimum added by pass dust is shown. Anyhow tiny increase of by pass dust, in spite of loss of pressure resistance in samples, is still acceptable conditions. The change in other important parameters of test concerning cement quality has been acceptable and this application process of by-pass dust has been confirmed. Thus, due to positive quality tests of cement resulted from mixture with percentage of by-pass dust and also easy conditions for application of this type of dust in cement mills of plants due to suitable mixture, preventing from environmental pollution and preserving natural sources, it is a suitable proposal. The ENV 197 standard under caption of tiny additives(zero up to 5 percentage) is admissible in case of passing relevant tests.

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